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Case Study

ECHINOCOCCOSIS: CURRENT INDIAN SCENARIO

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ABSTRACT
Hydatidosis/echinococcosis is one of the most widespread parasitic diseases costly to treat and prevent. It is caused by the larval stage of tiny tapeworm of dog *Echinococcus granulosus*. Despite some progress in the control of echinococcosis, this zoonosis continues to be a major public health problem in developing countries, and in several others, it constitutes an emerging and re-emerging disease. The ever increasing human population, growing demand for animal proteins as well as food supply provided an opportunity for the spread of echinococcosis. Although new sensitive and specific diagnostic methods and effective therapeutic approaches against echinococcosis have been developed few years before but only diagnosis and treatment can not be the solution for the control of echinococcosis as it is a public health problem. Therefore, to control this disease there is a need for collaboration between health authorities and, in particular, between both the veterinary services and public health services at a national level. Therefore it is appropriate to provide regular updates on it. By considering these facts, this review was designed to provide a baseline for developing strategies for *E. granulosus* parasite by knowing the epidemiological status of the disease in dogs, food animals and human population of the India.

KEY WORDS: Echinococcosis, dogs, food animals, humans, public health, one health, etc.

INTRODUCTION
Since man had started hunting of animals for food and domestication of the wild animal, he became prone to the disease of animals and vice versa. This intertransmission of diseases between humans and animals was earlier known as Zoonoses. Finally WHO had defined zoonoses are the infections or diseases which get naturally transmitted between vertebrate animals and man with a varied epidemiology, clinical features and control measures (WHO, 1959). Echinococcosis (hydatidosis or hydatid disease) is one of the zoonotic infections caused by the larval stages of metacestodes (tapeworms) of the genus *Echinococcus* (family Taeniidae). Echinococcosis has a major constraint on the livestock productivity since the time of Hippocrates (Gemmell and Roberts, 1998). Because of its extensive distribution throughout the world its prevention is one of the dynamic programs of the WHO. Its place is second in helminthic disease of significance (Sangaran *et al.*, 2014). The term hydatidosis is restricted to infection with the metacestode, while echinococcosis is applied in a general way to both adult and larval infections (NICD, 2005). Six species of echinococcosis have been recognized till date, but only four are of public health concern and these are *E. granulosus, E. multilocularis, E. vogeli* and *E. Oligarthrus* (Table 1). These four species are morphologically distinct in both adult and larval stages. Two new species have been recently identified i.e. *E. shiquicus* and *E. felidis* in small mammals and in African lions respectively, but their zoonotic transmission potential is unknown (Moro and Schantz *et al.*, 2016).

Cystic echinococcosis (CE) and alveolar echinococcosis (AE) are two most important forms of echinococcosis which are of medical and public health relevance in humans (WHO, 2016). In India, the authentic reports on the occurrence of CE in humans are available in the literature since 1935 onwards (Bhalerao, 1935). However, as India is non-endemic, scanty literature is available regarding the alveolar echinococcosis (Madhusudhan *et al.*, 2016). In some wealthy countries, CE has been successfully controlled or indeed eradicated (Torgerson and Budke, 2003) but, in Indian scenario, *E. granulosus* freely completing the life cycle due to some favorable conditions. Although various studies which have been reported on occurrence and prevalence of CE in different regions of India but there are very few published studies on CE in humans and animals together. Therefore the aim of this review is to bridge the information on the prevalence of CE and its associated risk factors in definitive host, slaughtered food animals and humans.

TABLE 1: Species characteristic of the genus *Echinococcus*

Species	*E. granulosus*	*E. multilocularis*	*E. oligarthrus*	*E. vogeli*
Length	3 to 6 mm	1.2 to 3.7 mm	up to 2.9 mm	up to 5.6 mm
Disease	*Cystic echinococcosis*	*Alveolar echinococcosis*	*Unicystic echinococcosis*	*Polycystic echinococcosis*
Distribution	*Worldwide*	Mostly Northern hemisphere	Central and South America	Central and South America
Larval Stage	Various organs	Liver	Various organs	Various organs
Definitive Host	Dogs or other canids	Foxes or other canids	Wild felids	Bush dogs and dogs
Intermediate Host	Domestic animals	Small rodents	Rodents	Rodents

LIFE CYCLE OF PARASITE

The life cycle of *Echinococcus* spp. involves two hosts and a free-living egg stage. CE is principally maintained in a dog–sheep–dog cycle, yet several other domestic animals may be involved (WHO, 2016). The adult *E. granulosus* resides in the small bowel of the definitive hosts i.e. dogs or other canids. Heavily infected dog alone can infect intermediate hosts over a wide area. Dogs show a natural resistance to infection and weak acquired immunity which may affect both the numbers of worms that establish themselves in the host and their size. Definitive host passes the eggs into their feces which gets released into the environment from gravid proglottids and ingested by the suitable intermediate hosts; here humans are the accidental dead end host for echinococcosis (CDC, 2013). These egg hatches in the small intestine of the intermediate host, oncosphere get released which penetrates the intestinal wall and enters into circulatory system from where it migrates into various visceral organs and forms the cysts of different sizes. When definitive host ingests cyst-containing organs of the infected intermediate host they again become infected. Protoscolices evaginate in the intestine of the definitive host, attach to the intestinal mucosa and develop into the adult stage. Although the adult parasite is not pathogenic but the larval or metacestode stages can be highly pathogenic in the intermediate host especially in humans, some of which have a high fatality rate. However, domestic animals are generally asymptomatic.

FAVOURABLE CONDITIONS FOR PARASITIC GROWTH IN INDIA

Past surveys of hydatid infection in carnivores, food producing animals and humans of India have uncovered that, several factors such as environmental, agricultural, cultural, educational and socioeconomical contribute for the transmission of infection. The conditions for the establishment and transmission of hydatidosis in both livestock and humans are extremely perfect in India (Singh *et al.*, 2013). The components which may support the development and maintenance of echinococcosis in India are

1. Livestock production mainly depends on extensive grazing system and hundreds of millions of peoples depends on animal power for cultivation planting, weeding, threshing and transporting
2. Numerous rural families have limited piece of land where they keep different animal species of animals
3. Dog population here is with high infestation rate and insufficient treatment
4. Vegetables accessible to dog defecation are used by families especially in rural communities and these vegetable are served in restaurants
5. Home slaughter especially for religious events in rural communities is common practice
6. Open slaughter is largely practiced and dogs are fed on offal of other animal carcasses
7. Abandoned abattoir exists but are insufficiently equipped and are accessible to dogs
8. Animal industry workers health education are often neglected
9. Ancient beliefs persist and mass media often spread contradictory information

INDIAN SCENERIO OF ECHINOCOCCOSIS

Echinococcosis in the definitive host is well recognized and has been studied in developed countries, but in India canine echinococcal zoonoses pose a lowly prioritized public health problem although conditions here are conducive for transmission. Accurate diagnosis and prevalence of *Echinococcus* infection in the definitive hosts should always be an important component for establishing epidemiological parameters of echinococcosis and preventing human and livestock infection. Regarding prevalence of echinococcosis in dog population of India Deka *et al.*, 2008 recorded 17.02%, 27.77% and 18.18% prevalence in stray dogs around abattoir in states of Assam, Meghalaya and Mezorum respectively, Prathiush *et al.*, 2008 recoded 4.35% prevalence in stray dogs in the Bangalore urban district, Singh *et al.*, 2014 recoded 0.84% prevalence in naturally infected dogs and Nikale *et al.*, 2014 reported the 5.22% prevalence in dog population of Maharashtra.

Studies on echinococcosis in intermediate host based on post-mortem inspection have indicated the prevalence of hydatidosis ranging from 0.41% to 50.96% in five species of food animals i.e. cattle, buffalo, sheep, goat and pig (Table 2). The highest prevalence has been reported in Punjab compared with other parts of the country. The existence of disease in food producing animals to such extent will not only affect the nation's economy but also health of the peoples. With respect to CE study in human population of India there are various reports and hospital-based studies but very few epidemiological studies or surveys (Table 3). Although Singh Nikale *et al.*, 2013, Nikale *et al.*, 2014 and Fomada *et al.*, 2002 have studied seroprevalence of disease in human population but these are restricted to limited geographical area. Therefore a joint program to discover the disease burden in animals as well as in human will be very much helpful, as it will reduce the economic cost of the program by diverting all the prevention and control aid only to the affected category, and sparing the resources that will be used in non affected one.

TABLE 2: Published literature on prevalence of hydatidosis in food animals

SN	Authors	Location	Prevalence (%)	Conclusion
1.	Deka *et al.,* 2008	Assam	C-16, B-6.52 G-4.87, P-0.43	Prevalence of disease in all food animals
2.	Deka *et al.,* 2008	Meghalaya	C-21.4, P-0.34	High prevalence in cattle
3.	Pednekar *et al.,* 2009	Deonar Abattoir, Mumbai.	C-5.10, B-3.8, P-0.87, S-0.75	Significant prevalence of disease in all food animals
4.	Singh *et al.,* 2012	Different Slaughter house / shops in northern India	C- 5.39, B-4.36, P-3.09, S-2.23 G-0.41	Significant prevalence of disease in all food animals
5.	Jatav and Garg *et al.,* 2012	Cantonment Board, Slaughter house, Mhow (MP)	B-1.19	Malnutrition plays significant role in prevalence
6.	Khan *et al.,* 2013	Mirah Export Pvt. Ltd. SAS Nagar Chandigarh Mohali	B-50.96	Prevalence may be due to overpopulation of stary dogs
7.	Jadhav *et al.,* 2013	M.K. Overseas Pvt. Ltd, Derabassi, Punjab	B-11.2	Lung condemnation due to hydatidosis was relatively higher than liver.
8.	Bengale *et al.,* 2013	Different slaughter houses of Maharashtra	C-2.68, B-0.85, S-0.77, P-1.08	Detail assessment of disease burden in the community eliminate the risk to humans
9.	Sangaran *et al.,* 2014	Corporation Slaughter house Chennai	S-6.5, G-5.8	Sheep plays major role in disseminating infection to dogs
10.	Godara *et al.,* 2014	R.S. Pura, Jammu	G-1.19	Slaughter at an early age would help to reduce the prevalence
11.	Sajjan *et al.,* 2015	Deonar Abattoir, Mumbai	P-1.37	Most prevalent in domestic pigs under free range system of rearing

C-Cattle, B- Buffalo, S-Sheep, G-Goat and P-Pigs

TABLE 3: Published literature on prevalence of CE in humans

S N	Authors	Region/ Area	Prevalence	Conclusion
1.	Akther *et al.,* 2011	MGIMS, Sewagram, Maharashtra	1996-2006 (117 patients)	CE common among house wives involved in rearing sheep and goat
2.	Makwana *et al.,* 2013	C.U. SHAH Medical College Surendranagar, Gujarat	2003-2012 (47 patients)	CE is predominantly present in rural & urban region of Gujarat.
3.	Rao *et al.,* 2012	MGIMS, Sewagram, Maharashtra	1997-2004 (91 cases) 2005-2007 (26 cases)	Epidemiology of CE in rural region of Indian subcontinent
4.	Singh *et al.,* 2013	Punjab	15.43 % seropositivity	High seroprevalence among occupational risk groups
5.	Md. Khader Faeheem N *et al.,* 2013	Hospitals in central and southern epidemic zone of Andhra Pradesh	2009-2011 (118 cases)	Emerging problem and in a course of challenge to all medical practitioners.
6.	Kayal and Hussain *et al.,* 2014	JLN medical college and hospital Ajmer, Rajasthan	2009-2011 (25 cases)	Majority cases were from rural areas. Incidence at unusual site in India is higher than other parts of world
7.	Nikale *et al.,* 2014	Abattoir and veterinary hospital workers, Mumbai	11.57 % Seroprevalence	High seropositivity was recorded in dog handlers
8.	Nikale *et al.,* 2014	Sion hospital and KEM hospital, Mumbai	2012-2014 (30 cases)	Housewives and students were more likely to be seropositive
9.	Fomada *et al.,* 2002	Different districts in the Kashmir region (North India)	5.03% Seroprevalence	Presence of asymptomatic infection in human which may lead to symptomatology and complications
10.	Kasat *et al.,* 2016	Tertiary care center in Mumbai, Maharashtra	1997-2007 (23 cases with pulmonary hydatidosis)	Pulmonary hydatidosis is very common even in nonendemic areas with challenging diagnosis and management
11.	Jaspal *et al.,* 2016	Jaspal Hospital, Ambala, Haryana.	2013-2015 (7 cases)	Laparoscopic approach eliminates the disadvantages of big surgical incision, reduces post-operative pain and shortens the hospital stay

STRAINS OF *E.GRANULOSUS* SPECIES

Molecular studies using mitochondrial DNA sequences have identified 10 distinct genetic types of *E. granulosus* till date (McManus and Thompson *et al.,* 2003). These include sheep strains (G1), Tasmanian sheep strain (G2), buffalo strain (G3), horse strain (G4), cattle strain (G5), camelid strain (G6), pig strain (G7), cervid strain (G8), ninth genotype (G9) has been described in swine in Poland and tenth strain (G10) in reindeer in Eurasia (5). Recently it has been proposed that *E. granulosus* genotypes should be split into 4 species: *E. granulosus* sensu stricto (genotypes G1–G3), *E. equines* (G4), *E. ortleppi* (G5) and *E. canadensis* (G6–G10) (Nakao *et al.,* 2007, Huttner *et al.,* 2008, Thompson, 2008). Globally, most human cases of CE have been found to be infected with sheep strain (G1) of *E. granulosus* (Moro and Schantz, 2009). All strains of *E. granulosus* have been found to infect the humans except G4 genotype (Sharma *et al.,* 2013). The strain variation in parasite influences the host specificity, life-cycle patterns, development rate, transmission dynamics, antigenicity and sensitivity to chemotherapeutic agents (Craig *et al.,* 2007). Information regarding the strains of parasite plays an important role to formulate control strategies by developing vaccines and diagnostic reagents for the prevention of transmission of disease.

Earlier studies about the strains of *E. granulosus* in livestock of Eastern India demonstrated the presence of four genotypes G1, G2, G3 and G5 (Bhattacharya *et al.,* 2007). Gudewar Craig *et al.,* 2009 demonstrated G1, G2 and G3 isolates in livestock of West Bengal. Pednekar Craig *et al.,* 2009 demonstrated the presence of 4 different genotypes i.e. G1, G2, G3 and G5 genotype in food producing animals in Maharashtra and adjoining area of Western India. Singh *et al.,* 2012 demonstrated the G1 and G3 genotypes in livestock of North India. Sharma *et al.,* 2013 demonstrated the zoonotic potential G1 and G3 strain as predominant genotypes infecting humans in India, the first human CE case infected with G5 genotype in an Asian country and presence of the G6 genotype in India. However, to date, very few reports are available regarding genotypes of E. granulosus infecting human in India. Therefore, a detailed investigation on the genotype of *E. granulosus* within a large geographical area of India has yet to be performed.

PUBLIC HEALTH RISK

CE occurs mostly in poor communities raising sheep and other livestock and involving dogs as guarding animals. Similarly, Animal handlers, dog owners, veterinarians and laboratory workers are also at higher risk of infection, since the eggs can contaminate water, fruits and vegetables or can stick to the fur of an animal and can be transferred from hands to the mouth of humans.

In humans, infection of hydatid cyst remains silent for years before the enlarging cysts cause symptoms in the affected organs. Cysts may develop in any internal organ like liver, lung, heart, bone, muscles or nervous system by hematogenous dissemination. Most commonly infected organs are liver and lungs. Pathogenecity of the cyst depends on the severity of the infection and the organ in which it is situated (Battelli, 2009). Non-specific signs include anorexia, weight loss and weakness. Other signs depend on the location of the hydatid cyst and the pressure exerted on the surrounding tissues. Hydatid cysts in the liver cause hepatic enlargement, right epigastric pain, nausea, vomiting and allergic manifestations after rupture or leakage of the cyst. Complications that may exist which include traumatic or spontaneous rupture, thoracobilia and biliarv fistula. If the lung is affected, clinical signs include chest pain, coughing, dyspnea, and hemoptysis. The diagnosis of CE is based on ultrasound imaging which is usually complemented or validated by computed tomography (CT) or magnetic resonance imaging (MRI) scans, radiography, serological tests, biopsies and ultrasound-guided punctures may also be performed for differential diagnosis. Treatment of CE can be done by different way depends on the cyst characteristic percutaneous treatment of with the PAIR (Puncture, Aspiration, Injection and Re-aspiration) technique, surgery, chemotherapy with benzimidazole compounds (WHO, 2016).

SOCIOECONOMIC CONSEQUENCES

In spite of the socio-economic significance, CE is considered as neglected zoonosis this might be due to little interest shown by the health services, decision makers, media and lack of information about the disease and official reports (NDDB, 2016). Socio-economic consequences of echinococcosis are related to both livestock and human infections and to the costs of control programs. Total livestock population of India is 512.10 million (Benner *et al.,* 2010). The rising of livestock is important and often the main source of income for millions of small holders. However, the contribution of these livestock resources to the national economy is proportionally small. Amongst the many prevalent livestock diseases, parasitism reports major constraints to livestock development and hydatidosis is one of the most important diseases which affect the efficiency of livestock. The major animal associated economic losses arises are loss of revenue through offal condemnation, losses in productivity such as reduction in carcass weight, milk production, fleece and wool value, fertility, hide values, delayed performance and growth, cost involvement in the disposal of infected viscera of dead animals (Vaidya *et al.,* 2014). The public health economic significance of hydatidosis lies on the cost arise through diagnostic procedures, the cost of hospitalization, chemotherapeutic treatments, surgical fees, loss of income, permanent or temporary incapability to work, life impairment and fatalities (Ghodake *et al.,* 2014). Regarding the economic losses in food producing animals some attempts have been made to calculate the cost involved in organ condemnation in some areas. Vaidya et al. (45) estimated economic impact based on number of animals slaughtered per year in Maharashtra which was found to be Rs. 26, 78, 721.49. Sajjan et al. (24) estimated economic loss due to the condemnation of edible offals in hydatid infested pigs at Deonar abattoir, Mumbai for a period of four months

Rs.1,248.90 and based on this figure calculated projected annual economic loss was Rs. 1,1396.10. Similarly, calculated economic loss by Ghodke et al. (46) in cattle due to condemned liver was Rs. 1434 which was higher as compared to loss caused by condemned lung (Rs.620.4) and spleen (Rs.91.75).

The economic losses due to CE of the livestock and human in India was first time systematically analyzed Singh *et al.*, 2013. The analysis revealed a total annual median loss of Rs. 11.47 billion. Cattle and buffalo industry accounted for most of the losses i.e. 93.05% and 88.88% of the animal and total losses, respectively. Human hydatidosis related losses were estimated to be Rs. 472.72 million but are likely to be an under-estimate due to under-reporting of the disease in the country.

CONTROL PROGRAMME

The scarcity of reliable data and reports across India is the main constraint of control programs. Control programs for echinococcosis can be successful but require a long period of intervention based primarily on dog-targeted control measures. Effective control is based on presentation by breaking the cycle between definitive and intermediate host. The success of a control program often depends on the structure and sustainable funding of the control authority and team and the willingness of target communities to participate, rather than on the technical tools and approaches available.

Dog population related control measures include registration of dogs, treatment of dogs which get access to households, an adaptation of hygienic practices while maintaining pet dogs and limiting mongrels by proper birth control programs. Improved post mortem inspection of slaughtered animals, food inspection and slaughterhouse hygiene is necessary. Other interventions include changing home-slaughter practices, proper cooking of food, protected water supply at home, avoid eating raw vegetables, health education can increase participation and maintain the continuity of long-term control, especially in the consolidation phase. The advent of a new vaccine for livestock may help reduce the time required to interrupt transmission between definitive host and intermediate host and the risk of human exposure. Vaccination of lambs can be an additional intervention. A program combining vaccination of lambs, deworming of dogs and culling of older sheep could lead to an elimination of CE disease in humans in less than 10 years (6).

CONCLUSION

From this review it can be concluded that echinococcosis had a significant economic and public health impact, therefore a systematic study on this zoonosis is required to make the final comment on these observations. This review highlights an urgent need of further studies rural areas and a science based policy to control and manage the disease in the country. As a ‘One Health’ approach it is essential that coordinated efforts to be made by veterinary and medical science along with local governing authorities to minimize prevalence echinococcosis in animals and humans. Adequate extension work regarding echinococcal zoonosis will be conductive to improve people participation in control and eradication programme.

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